Next Generation Optics in Meta Data Centers - 200G and 400G pluggable optics
Next Generation Optics in Meta Data Centers - 200G and 400G pluggable optics

Qing Wang, Optical Engineer, Meta
Abhijit Chakravarty, Tech. Lead Manager, Meta
Thang Pham, Optical Engineer, Meta
Vincent Zeng, Manufacturing Quality Engineer, Meta
Ruby Chen, Tech. Sourcing Manager, Meta
Agenda

• Meta pluggable optics evolution
• 200G optics
  ○ Specs and performance in the early deployment
  ○ Manufacturing at scale
• 400G optics
  ○ Specs optimization
  ○ Quality and Manufacturing challenges
• Meta Sourcing strategies for pluggable optics
• Conclusion
Meta pluggable optics evolution

**2017**
- 12.8T Switch
  - Radix * Optics Speed: 128 * 100GbE
  - NRZ

**2021**
- 25.6T Switch
  - Radix * Optics Speed: 128 * 200GbE/ 64 * 400GE
  - PAM-4

**Next Gen**
- 51.2T Switch
  - Radix * Optics Speed: 128 * 400GbE/ 64 * 800GbE
  - PAM-4

- **100G QSFP28 CWDM4**
  - (4 x 25G Host/ 4 CWDM WLs)

- **200G QSFP56 FR4**
  - (4 x 50G Host/ 4 CWDM WLs)

- **400G QSFP56DD FR4**
  - (8 x 50G Host/ 4 CWDM WLs)
200G FR4 Optics
## Meta 200G FR4 key specs

<table>
<thead>
<tr>
<th>Item</th>
<th>Min</th>
<th>Max</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form factor</td>
<td>QSFP56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management interface</td>
<td>CMIS 4.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation mode</td>
<td>100G/200G</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power consumption (W)</td>
<td>-</td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td>Case temperature (°C)</td>
<td>15</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Wavelength N (nm), N=0,1,2,3</td>
<td>1271+N*20-5.75</td>
<td>1271+N*20+5.75</td>
<td>WL range reduced from +/-6.5nm (IEEE) to +/-5.75nm (Meta)</td>
</tr>
<tr>
<td>Tx OMA (dBm)</td>
<td>-2.2</td>
<td>4.5</td>
<td>Minimum Tx OMA reduced by 1dB compared with IEEE</td>
</tr>
<tr>
<td>Rx OMA (dBm)</td>
<td>-7</td>
<td>4.5</td>
<td>Minimum Rx OMA reduced by 1dB compared with IEEE</td>
</tr>
<tr>
<td>Operating range</td>
<td>2m to 3km</td>
<td></td>
<td>IEEE FR4 specs is 2m to 2km</td>
</tr>
</tbody>
</table>

- Specs optimized based on Meta use case to improve the yield, support high volume, and promote integrated optics technology
Meta 200G FR4 Optics qualification

• Host systems
  ○ Minipack 2, Wedge400 etc
• Process
  ○ Spec Definition
  ○ Component level qualification (O/E performance, power/thermal/mechanical, interoperability, FW, EEPROM)
  ○ System level qualification (Interoperability, EMC, FW, power/thermal/mechanical, communication interface, module management)
Key performance metrics in the early deployment

- Early deployment data indicated good margin in the module performance
The global COVID-19 crisis has impacted normal business operations (in-person mfg. audits)

- Meta’s innovative virtual video audit process
  - Multiple cameras are used to view the entire production floor
- Audit can be held over multiple days to allow for adequate time and focus on particular topics
- LIVE virtual video audits enable more attendees from Meta for a more comprehensive meeting
- Virtual Audits still align with our structured audit procedure
- Eliminate COVID 19 travel restrictions
- Multiple sites can be audited within a short period of time
- Production stations can be viewed closely
Meta 200G FR4 MP challenge and strategy

Post-Production: Global material shortage & ~4X PCN(s) qualification

- High demand for 200G FR4 in 2021, 2022 & beyond
  - Material inventory, capacity Ramp strategy, PCN Qual (Dual Source)
- Mfg. Ramp Enablement
  - Mfg. and test capacity ramp analysis
  - Yield improvement, production line throughput and utilization assessment
  - Monthly capacity ramp audits for multiple mfg. sites
- Risk Mitigation
  - Quality control process/Milestone review
  - Customized ORT & long-term reliability processes
- Dual Sourcing
  - Critical components via ECN/PCN
- New supplier qualification to de-risk supply
Meta 200G FR4 MP challenge and strategy

Post-Production: Meta’s long-term reliability for pluggable optics

- **Test setup & conditions**
  - Multiple OCP switches (Wedge for 100G, Minipack for 200G)
  - Thermal chamber for continuous TC test
  - 0 degree C to 65 degree C optics case temp (4-5 cycles/day)
  - Critical parameter monitoring (24X7) such as Tx power, Rx power, Bias, Temp etc.
400G FR4 Optics
Meta 400G FR4 Specs optimization

- **Requirements:**
  - Support Meta’s new switches such as W400, Minipack2, Arista 7388
  - Fully backward compatible with 200G QSFP56
  - Optically forward compatible with 800G optics

- **Specs development:**
  - IEEE 802.3cu is the baseline
  - Temperature range is reduced to 15-70°C
  - Customized lane mapping to fully support backward compatibility
  - Full specs also include Management, EMC, Quality and Reliability...
  - Specs is submitted to OCP for review and approval
## 400G FR4 key specs

<table>
<thead>
<tr>
<th>Specification</th>
<th>Min</th>
<th>Max</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form factor</td>
<td>QSFP-DD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management interface</td>
<td>CMIS4.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation mode</td>
<td>400G/200G</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power consumption (W)</td>
<td>10.5</td>
<td>7.0</td>
<td>400G mode, 200G mode</td>
</tr>
<tr>
<td>Temperature(°C)</td>
<td>15</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Operating range</td>
<td>2m to 3km</td>
<td></td>
<td>IEEE FR4 specs is 2m to 2km</td>
</tr>
<tr>
<td>Link loss (dB)</td>
<td></td>
<td>4.0</td>
<td>Same as IEEE FR4</td>
</tr>
<tr>
<td>Wavelength range (nm)</td>
<td>1265.25</td>
<td>1276.75</td>
<td>WL range reduced from 13nm to 11.5nm</td>
</tr>
<tr>
<td></td>
<td>1285.25</td>
<td>1296.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1305.25</td>
<td>1316.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1325.25</td>
<td>1336.75</td>
<td></td>
</tr>
<tr>
<td>Lane mapping</td>
<td>(Host side) (1,5), (2,6), (3, 7), (4, 8)</td>
<td>1, 2, 3, 4 (Line side)</td>
<td>200G mode uses host lanes 1-4 similar to 200G QSFP56</td>
</tr>
</tbody>
</table>
Optics Reliability and Quality Assurance

- Reliability and Quality Performance Target for the module established

<table>
<thead>
<tr>
<th>Lifetime and Target FIT/MTBF/AFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device Level</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>Current Integrated Optical Device</td>
</tr>
</tbody>
</table>

- Reliability comes from build rather than test-ensure the smooth production steep ramp
  - Mode hopping control from laser die, COC and module level
  - Laser Burn-In optimization to drive down the FIT (mainly infant mortality)
  - Consistent process for building block for different SKUs

- Operational Control Quality
  - ORT (Ongoing Reliability Test) in place
  - MAP (Manufacturing Analytics Portal) in place
Meta Optics Sourcing Strategy

**Performance**
- Preserve best of breed technology optionality and encourage optical innovation
- Examine trade-offs to achieve optimal optical performance per use case (e.g. bandwidth, power consumption, port density, quality and reliability)

**Upgradeability**
- Minimize disruption to network during upgrades
- N-1 Gen backward compatible mode validation requirement.
- N+1 Gen forward compatibility desirable

**Infrastructure Reuse**
- Compatibility with existing network topology -> scale up switch bandwidth while preserving radix and fiber cabling (e.g. standard duplex LC requirement)
- Maintain networking power footprint gen over gen

**Ecosystem**
- Interoperability and flexibility – open, standardized interfaces
- Engaging comprehensive levels of the supply chain to address market challenge
Call for Action

Meta has started deployment of 200G and 400G optics on 25.6Tbps switch fabric in our data centers. Specification is optimized in both optics to address the scale for Meta deployment.

- DFx for Security of Supply from component level to module level
- Technology with higher degree photonic integration
- Time to Market
- Power/Thermal/Mechanical/EMC
- Enhanced Telemetry/Diagnostic Capability
- Reliability
- Standard Alignment

OPEN POSSIBILITIES.
# Meta contributors (Alphabetical)

<table>
<thead>
<tr>
<th>Absar Ulhassan</th>
<th>Dennis David</th>
<th>Rob Stones</th>
<th>Song Yu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anju John</td>
<td>Freddy Mercado</td>
<td>Lingjun Wu</td>
<td>Tian Fang</td>
</tr>
<tr>
<td>Aron Bishop</td>
<td>Hany Morsy</td>
<td>Kevin Hicks</td>
<td>Tom McCandlish</td>
</tr>
<tr>
<td>Chenfei Lin</td>
<td>Harshit Gulati</td>
<td>Max Devyatov</td>
<td>Victor Blake</td>
</tr>
<tr>
<td>Chet Powers</td>
<td>Herman Chin</td>
<td>Melody Liu</td>
<td>Vignesh Vijayanath</td>
</tr>
<tr>
<td>Chintu Abraham</td>
<td>Ivy Wu</td>
<td>Nadim Sarras</td>
<td>Vimal Vasudevan</td>
</tr>
<tr>
<td>Chris Berry</td>
<td>James Stewart</td>
<td>Naomi Kalyani</td>
<td>Xuan He</td>
</tr>
<tr>
<td>Chris Olesiewicz</td>
<td>Jeff Price</td>
<td>Nhan Hoang</td>
<td>Xu Wang</td>
</tr>
<tr>
<td>Chunliang Zheng</td>
<td>Jimmy Leung</td>
<td>Rajan Kumar</td>
<td>Yevgeniy Rombakh</td>
</tr>
<tr>
<td>Danielle Murphy</td>
<td>Jiu Xu</td>
<td>Sami Khan</td>
<td>Yishen Huang</td>
</tr>
</tbody>
</table>
Open Discussion
400G-FR4 Electrical/optical lane mapping

- To support 200G backward compatibility requirement, the mapping of electrical input/output lanes from QSFP-DD connector to optical wavelengths of the 400G-FR4 module is customized.
- In 200G mode, 4 active host lanes are 1-4, similar to 200G QSFP56.